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Case Study

ENERGY CONSUMPTION PATTERN AND ENVIRONMENTAL IMPLICATIONS IN COMMERCIAL SECTOR: A CASE STUDY OF AN INDIAN CITY

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ABSTRACT

Energy input is vital in every sector for survival and growth. The commercial buildings are typically all buildings, which are not residential, industrial, or agricultural. The sector includes service businesses, such as shops and stores, hotel, restaurants, as well as a wide range of facilities. The commercial sector alone consumes around 20% of the total energy. The main reason is that, there is a lot of energy wastage in the commercial sector. For a developing country like India, characterized by severe energy shortages, the need for energy conservation is of most priority. The energy efficiency improvements in such sector go a long way in their substantial development. In this backdrop, the paper analyzes the energy consumption and environmental impact in commercial sector of Davangere, Karnataka state, India. The energy consumption pattern is studied and energy efficiency is estimated in terms of Specific Energy Consumption (SEC). Further, energy consumption potential is estimated. The environmental impact in terms of Carbon dioxide (CO_2) emission is estimated and also wide ranges of energy saving options are identified. The factors influencing the energy efficiency and energy consumption in these sectors is also studied. The factors are analyzed using multiple regression models.

KEYWORDS: Commercial Sector, Energy, Energy Efficiency, Sustainable Development, Specific Energy Consumption

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INTRODUCTION

The sector, which accounted for 7 percent of total delivered energy consumption in 2008, encompasses many different types of buildings and a wide range of activities and energy-related services. Commercial energy use grows by an average of 1.5 percent per year from 2008 to 2035. Examples of commercial sector facilities include stores, commercial institutions, restaurants, hotels, museums, office buildings, banks, and sports arenas. Most commercial energy use occurs in buildings or structures, supplying services such as space heating, water heating, lighting, cooking, and cooling. World energy consumption is likely to increase by 53 percent, from 505 quadrillion Btu in 2008 to 770 quadrillion Btu in 2035 [1]. India is one of the largest countries in the world, with a geographical area covering 3 million km^2 and with a population of over 1 billion. The Indian economy has clocked an average growth rate of 7 percent in the last decade. To maintain this pace, experts believe that the country will have to increase its energy consumption by at least 4 percent annually. The growth rate of the demand for power in developing countries is generally higher than that of the gross domestic product (GDP). The elasticity ratio for the growth rate in demand of power over that of GDP is about 1.5 for India. In order to support a reasonable rate of

growth of GDP, around 7% per annum, the growth rate of power supply needs to be more than 10% annually. The government of India (GOI) has emphasized infrastructure development, with top priority given to the power sector. The Indian economy has clocked at an average growth rate of 7 percent in the last decade. Experts believe that the country will have to increase its energy consumption by at least 4 percent annually. The economic growth of a nation calls for a matching rate of growth in infrastructural facilities [2]. As far as one can remember, Karnataka has been facing power crisis for more than 25 years. Brown outs and black outs have become regular features of the energy scenario whether reservoirs are full or not. Power crisis has become a perennial phenomenon. A State which had power surplus one time has been a power deficit State since a long time. Every new Energy Minister irrespective of party affiliation soon after assuming the portfolio makes tall promises to solve power crisis within a short time. As it is known truth that there has been no improvement in power scenario [3].

It is expected that global energy-related CO_2 emissions to level off around the year 2030, even as overall energy use continues to increase to support economic development and human progress around the world. This global emissions trend is the result of significant improvements in energy efficiency, plus shifts toward natural gas and other less carbon-intensive fuels, as efforts continue to manage the risks posed by rising greenhouse gas emissions. Concerns about the risks posed by rising greenhouse gas (GHG) emissions have prompted many countries to seek to curb their energy-related CO_2 emissions [4]. Energy efficiency does not necessarily mean conservation or cutting back. It means using energy resources more wisely and productively by taking advantage of the highly efficient technologies which are available. The notable achievements of countries like Japan, Germany and Sweden serve to emphasize that economic growth and improved living standards are not necessarily linked to growth in energy use. A study by Electric Power Research Institute had shown that, most efficient end-use technologies adoption had the potential of saving anywhere between 24 and 44% of the electricity in the year 2000 in USA. More specifically, the savings in the residential sector was estimated at 27-46%, in the commercial sector at 23-49% and in the industrial sector at 24-38% [5].

Because of the limited amount of non-renewable energy sources on Earth, it is important to conserve the current supply or to use renewable sources so that the natural resources will be available for future generations. Energy conservation is important because consumption of non-renewable sources impacts the environment. In a scenario where India tries to accelerate its development process and cope with increasing energy demands, conservation and energy efficiency measures are to play a central role in energy policy. A national movement for energy conservation can significantly reduce the need for fresh investment in energy supply systems in coming years. It is imperative that all-out efforts are made to realize this potential. Energy conservation is an objective to which all the citizen in the country can contribute.

This paper investigates the energy consumption using consumption patterns, environmental impact of energy usage in the commercial sector. The energy consumption pattern is based on different energy carriers used in the sector and also based on the specific parameters like family size, area of energy utilization. The factors influencing the energy efficiency and energy consumption in commercial sectors is also studied. The various factors which influence the energy efficiency and also the energy consumption is examined using statistical tools. The analysis is carried out using the SPSS (Statistical Package for Social Science) version 20.

METHODOLOGY

The primary data required for the study is gathered through canvassing a structured questionnaire, administered personally. The questionnaire covered different aspects of commercial building energy consumption, energy consuming appliances and the attitude and behavior of individual towards energy etc. Nevertheless, the questionnaire for both the sectors had common sections covering following aspects:

- General Information of the Facility
- Demographic and Economic Background
- Different Types of Energy Consuming Devices Used
- Variables that Influence Energy Efficiency and Energy Consumption

A survey is conducted in various facilities in different locations of Davangere city. Socio-economic and energy data was collected from randomly selected samples. A sample of 50 commercial buildings like shopping malls, textile shops, hotels, showrooms, etc., is chosen for the pilot study. The questions specific to energy in the survey are on primary source of energy for lighting, cooling and cooking, etc. The other information required for achieving the stated objectives include: annual energy requirements (for lighting and cooking, etc.), CO_2 emission factor, and environmental factors. The data for estimating these parameters has been obtained from catalogues, journal papers and from equipment manufacturers.

RESULTS AND DISCUSSIONS

Energy Consumption Pattern in Commercial Sector

The energy consumption pattern is studied for the different commercial sector buildings from the energy data collected. Here, the energy data is collected for 50 commercial sector buildings like textile shops, showrooms, hotels, etc. From these data different energy consuming devices were considered. Generally in commercial sector buildings electricity, diesel and LPG (Liquefied Petroleum Gas) are the primary energy carriers. In commercial buildings the electricity is primarily used for lighting and for different devices like computers, fans, Air Conditioners (AC), printers, refrigerator, Television (TV), etc. LPG is the primary energy carrier for cooking purpose in the hotels and restaurants. The diesel is used in different commercial sector buildings for generators. The amount of electricity used is noted in terms of kWh. The LPG used for cooking collected was in terms Kg's and is then converted to kWh. Also the diesel used for generators is noted down in energy data in terms of litre, and then it is converted to kWh. The number of employees working in each commercial building is noted down during the survey. Also noted down is the floor space area for all the buildings.

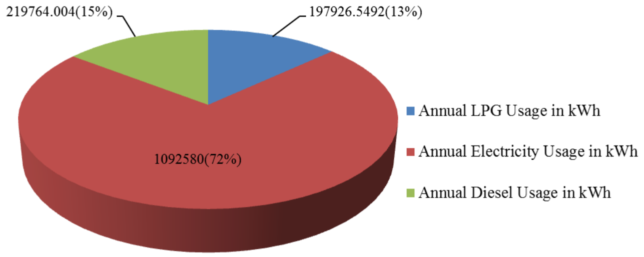

Figure 1: Energy Consumption Pattern by Energy Carrier Type

From Figure 1 it can be seen that, the annual electricity consumption is more in commercial sector buildings

compared to the annual diesel usage and annual LPG usage. About 72% of energy is supplied by the electricity, 15% by diesel and 13% is by LPG in all commercial sector buildings. The share of the electricity is more in commercial sector because most of the energy used in this sector is for lighting purpose, energy consuming equipment like fans, AC, computer, etc. Compared to residential sector, in commercial sector lighting is very basic need. Therefore, more lighting are provided in all buildings like textile shops, showrooms, hotels, etc. In all these, the main attraction for customer is because of the way lighting is provided and the comfort. Also, the electricity is required for the equipment's like refrigerator, mixer, grinders, etc., in hotels and restaurants. The diesel consumption has a share of 15%. The main reason for the use of diesel in commercial sector is for generators. When power failure occurs, the owners use generators for lighting and other purposes. LPG has a least share in commercial sector because; the LPG is used only for cooking purposes in hotels and restaurants.

Specific Energy Consumption (SEC)

From the energy data which are collected, total floor space area of commercial buildings is noted down in terms of sq. ft. The no. of employees working in the commercial buildings is also noted down while collecting the energy data. The specific energy consumption is calculated for energy consumed per sq. ft. of area. Then, specific energy consumption is calculated for energy consumed per employee in commercial buildings. In commercial sector, the energy used per sq. ft. of floor space area is represented in terms of SEC, Specific energy consumption is 7.0001 kWh/sq. ft. of floor space area. For each sq. ft. 7.0001 kWh of total energy is consumed in commercial sector. In this sector, energy used by an individual is represented as, Specific energy consumption is 4428.9451 kWh/employee. Each individual consumes about 4428.9451 kWh of energy annually. Although this value is less compared to developed countries, it is much more compared to previous year values in India and it is increasing much rapidly.

Another Energy efficiency indicator i.e., economic-thermodynamic indicators, popularly called Energy Intensity (EI) is also computed in this study. EI is calculated by using energy data which are collected during the survey, as follows:

Energy Intensity (EI) is 75.0035 kWh per lakh rupee of annual turnover.

Environmental Impact in Commercial Sector

The commercial sector includes the wide variety of buildings used by businesses, organizations, and government agencies, including office buildings, hotels and multi-storey apartments, shopping malls, etc. The bulk of greenhouse gas emissions caused by these buildings is from energy use for heating, cooling, and lighting, with additional use for refrigeration, electronic equipment, and other operations. The emission of CO_2 is calculated for different energy consuming products in commercial sector buildings.

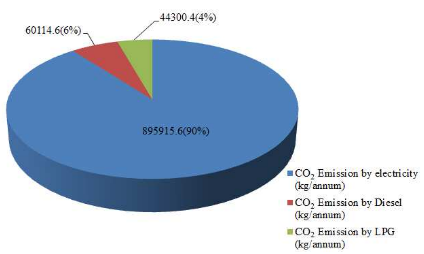

Figure 2: Annual CO_2 Emission by the Type of Energy Carrier

To calculate CO_2 emission, the emission factor for electricity, diesel and LPG is required. The emission factor for

electricity is 0.82 kg CO_2/kWh, for diesel is 2.734 kg CO_2/ltr and for LPG is 2.9 kg CO_2/kg of LPG. For the calculation of CO_2 emission, total annual energy consumption and the annual usage of energy consuming devices are obtained. From figure 2, it is observed that, major contributor for CO_2 emission in commercial sector is electricity. The electricity causes about 90% of total annual CO_2 emission followed by diesel 6% and LPG 4%. In commercial sector lighting is used extensively. Hence, there is more annual CO_2 emission by electricity of about 895915.6 kg.

Energy Saving Options

The benchmarks for the monetary goals include reduced energy costs and reduced life-cycle costs of energy-consuming equipment relative to current and historic costs. Reduced total emissions of carbon dioxide, other gases and precursors to local pollution are measures of environmental progress. The energy use per square foot of a building is a measure of general energy efficiency. Consumers desire convenience, safety, reliability and service at minimal cost. Builders attempt to reduce production costs while satisfying the real and perceived needs of the consumers. Manufacturers create products for a market that includes consumers, contractors, retailers and builders. Energy suppliers need to deliver a product of uniform and consistent performance and value to their customers. A variety of energy saving options are available for the commercial sector. In this section, some of the strategies to save the energy consumption in commercial sectors has been discussed. Manufacturers of lighting equipment now offer a host of efficient lighting products for lamps of all sizes. From the energy data collected, it is possible to calculate how much energy will be saved and also how much electricity cost will be saved, if we use Compact Fluorescent Lamp (CFL) instead of Incandescent Lamp (ICL). By replacing just one 100W incandescent bulb in building with a 20W CFL there is reduction of annual CO_2 emission by a minimum of 191 kg and also a reduction of annual electricity consumption by 233.6 kWh. This is shown in the table 1.

Table 1: Annual Savings by Replacing ICL with CFL

Appliances	Annual Electricity Consumption (kWh)	Annual CO2 Emission (kg)	Annual cost Savings (Rs)
Incandescent Lamp (ICL)	292	239.44	2044
Compact Fluorescent Lamp (CFL)	58.4	47.88	408.8
Savings	**233.6**	**191.56**	**1635.2**

In almost all the commercial buildings computers basic need for the day-to-day life. If the laptop is used instead of desktop with CRT screen then there will be considerable savings. There will be reduction of CO_2 emission by 407 kg and reduction in electricity consumption by 496.4 kWh annually. This reduction is shown in the table 2. The cost saved is Rs. 3474.8 annually.

Table 2: Annual Savings by Replacing a Desktop with a Laptop

Appliances	Annual electricity consumption (kWh)	Annual CO_2 emission (kg)	Annual cost savings (Rs)
Desktop with CRT screen	584	478.88	4088
Laptop	87.6	71.83	613.2
Savings	**496.4**	**407.05**	**3474.8**

Commercial buildings differ substantially with regard to their use of appliances. Restaurants contain refrigeration,

cooking, and dishwashing equipment; hotels have clothes washing and drying facilities; and office buildings use a multitude of computer related equipment. Energy efficiency opportunities are available for virtually any energy using device. Some energy efficiency measures reduce the operating cost of existing equipment. Options include raising the temperature of refrigeration equipment, changing cooking practices to reduce energy waste, turning off computer and electronic equipment in the evening, recapturing heat from clothes drying equipment, etc. When equipment requires replacement, energy efficient units should always be selected. If a BEE (Bureau of Energy Efficiency) 5 star rated fan is used instead of a regular fan then it can reduce energy consumption, energy bills and carbon footprints. By the usage of 5 stars rated fans, there will be a reduction of annual CO_2 emission by 44 kg and reduction of annual electricity consumption by 53.65 kWh. These calculations are shown in the table 3.

Table 3: Annual Savings by Replacing a Regular Fan with a 5 Star Rated Fan

Appliance	Annual Electricity Consumption (kWh)	Annual CO_2 Emission (kg)	Annual Cost Savings (Rs)
Regular fan	237.25	194.55	1660.75
BEE 5 star rated fan	183.59	150.54	1285.13
Savings	**53.65**	**44.01**	**375.62**

If a 2 star AC is replaced by a 5 star AC; there will be drastic reduction in CO_2 emission and also in electricity consumption. If a 5 star rated split AC (1.5 ton) is used then there will be reduction of annual CO_2 emission by 766 kg and also the reduction of annual electricity consumption by 934.4 kWh (Table 4).

Table 4: Annual Savings in CO_2 Emission and Electricity Consumption by Replacing a 2 Star Rated AC with a 5 Star Rated AC

Appliance	Annual Electricity Consumption (kWh)	Annual CO_2 Emission (kg)	Annual Cost Savings (Rs)
1.5 ton split AC, 2 star	5752.4	4716.97	40266.8
1.5 ton split AC, 5 star	4818	3950.76	33726
Savings	**934.4**	**766.21**	**6540.8**

Factors Influencing Specific Energy Efficiency (SEC)

Total of 24 variables are selected from the questionnaire in order to find the main factors which influence the SEC in commercial sector. After completing the pilot study, a reliability test is run on the obtained data using SPSS (Statistical Package for Social Science) software version 20. One of the most commonly used reliability coefficient is 'Cronbach's Alpha'. This resulted in a Cronbach's alpha value of 0.761, and is considered to be satisfactory as it is greater than 0.60.

Factor analysis is used for data reduction and to identify a small number of factors that explain most of the variance that is observed in a much larger number of manifest variables. As Eigen values greater than one are only considered, a total of seven components from the extracted solution meet this criterion. The extracted seven components explained about 70% of the variability in the original 24 variables included in the study, as shown in Table 5. The total variance explained by each factor is listed in the column labelled Eigen value. The next column contains the percentage of

the total variance attributable to each factor. The last column, the cumulative percentage, indicates the percentage of variance attributable to that factor and those that precede it in the table. The factors are arranged in descending order of variance explained.

Table 5: Total Variance Explained for SEC

Component	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Eigen value	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.865	20.272	20.272	3.520	14.667	14.667
2	3.756	15.648	35.921	2.927	12.197	26.864
3	2.499	10.411	46.332	2.883	12.012	38.876
4	2.120	8.835	55.167	2.864	11.933	50.809
5	1.339	5.579	60.746	1.980	8.250	59.060
6	1.291	5.378	66.124	1.481	6.171	65.230
7	1.022	4.259	70.382	1.236	5.152	70.382

Table 5 shows that almost 70% of the total variance is attributable to the first seven factors. The remaining seventeen factors together account for only 30% of the variance. Hence, the complexity of the data got reduced considerably by the use of these seven components with only 30% loss of information. Thus, a model with three factors is adequate to represent the data.

The Scree plot shown in Figure 3 helps in determining the optimal number of components. It is a plot of the total variance associated with each factor. Typically, the plot shows a distinct break between the steep slope of the large factor and the gradual trailing off of the rest of the factors. Generally the components are extracted on the steep slope. The components on the shallow steep contribute little to the solution. The last big drop occurred between the 7th and 8th components. Hence, the first seven components are retained.

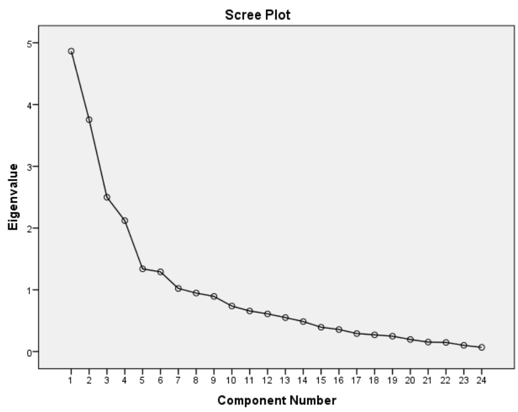

Figure 3: Scree Plot for the Variables

Under each of the derived component, all variables with correlation coefficients greater than 0.45 (as obtained by the rotated component matrix) are considered significant as shown in Table 6. Keeping these variables in mind the factors are appropriately named in this table. Subsequently, these factors have been ranked based upon the average factor scores.

Based on the rankings obtained, it may be observed that the ‘Subsidy factor’ is the most important factor and the ‘Knowledge factor’ is the least important one in influencing commercial sector’s adoption of energy efficiency. The pilot

study is conducted for different types of commercial buildings. In this, the people think that subsidy by the government should be provided and are important for energy efficiency. The second most important factor is 'Attitudinal factor'. The people are concerned about environment and they are willing to adopt and willing to invest in energy efficient technologies but they think that government should provide subsidies for these technologies. The third important factor is 'technology factor'. Good numbers of energy efficient technologies are used in the commercial sector and they are satisfied with these technologies. The awareness about general environmental issues is not so good in commercial sector.

The factors discussed above are considered as non-technical factors, these factors are obtained by the perception based analysis. Along with these factors, technical factors which are considered in the questionnaire are also considered for multiple regression analysis in order to analyse the factors influencing energy efficiency. Total eleven factors are considered for multiple regression analysis including seven non-technical factors and four technical factors. These four technical factors are number of energy star products, number of CFLs used, ratio of CFLs to ICLs used, and ratio of CFLs to tube lights used. These factors are directly measured through the questionnaire and are converted into five to one scale (Likert scale).

Table 6: Correlations, Factor Names and Rankings

Component	Variables	Correlations (Factor loadings)	Mean variable score	Average variable score	Factor name	Rank
1	i) Turnover	0.833	3.00	3.233	Economic factor	V
	ii) Expenditure	0.819	2.70			
	iii) Savings	0.751	4.74			
	iv) Ownership	0.633	3.40			
	v) Area of building	0.631	1.88			
	vi) Willingness to invest	0.432	3.68			
2	i) Liking towards technology	0.782	3.00	3.54	Technology factor	III
	ii) Degree of satisfaction	0.772	3.86			
	iii) Maintenance cost	0.689	3.76			
	iv) No. of energy efficient technology	0.503	3.54			
3	i) Attitude towards change	0.886	3.90	4.137	Attitudinal factor	II
	ii) Concern for environment	0.754	4.09			
	iii) Willingness to adopt	0.716	4.42			
4	i) Importance of technology	0.736	2.50	3.283	Govt. policy factor	IV
	ii) Govt. effort	0.709	3.96			
	iii) Risk coverage	0.696	3.02			
	iv) Govt. incentives	0.653	3.58			
	v) Regulations	0.506	3.28			
	vi) Initial investment	0.428	3.36			
5	i) Adequacy of information	0.788	3.50	3.067	Personal factor	VI
	ii) Awareness	0.700	2.78			
	iii) Ego, prestige, status	0.489	2.92			
6	i) Govt. subsidies	0.857	4.36	4.36	Subsidy factor	I
7	i) Education	0.823	2.60	2.60	Knowledge factor	VII

The factor scores obtained in principal component analysis are used in multiple regressions, with the SEC (kWh/sq. ft.) in the commercial sector as the dependent variable. In this result, the Adjusted R^2 of 0.692 and it has a reasonably good explanatory power. R (Multiple correlation coefficients) value of 0.873 indicated a strong relationship

between the dependent variable and the considered factors.

The standardized beta coefficients for all the factors are obtained by the Collinearity statistics table. It is found that Attitudinal factor (ATTDFACT) is less significant i.e., 0.755 (75%). This value should be less than 0.10 for significant result. Therefore, ATTDFACT is eliminated and again regression analysis is carried out for remaining ten factors. By doing this the adjusted R^2 value is increased to 0.699 and all the factors resulted significant as the significance values are within the limit (Table 7). By using the beta coefficients the regression equation is formed.

Table 7: Collinearity Statistics for SEC

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	40.704	3.226		12.617	0.000
	ECONFACT	3.939	0.573	0.816	6.869	0.000
	TECHFACT	-1.974	0.401	-0.409	-4.923	0.000
	GOVTPOLFACT	1.014	0.431	0.210	2.353	0.024
	PERSNFACT	-1.079	0.383	-0.224	-2.818	0.008
	SUBDYFACT	2.489	0.498	0.516	4.998	0.000
	KNWDGFACT	1.028	0.409	0.213	2.511	0.016
	NOFSTRPROD	-1.604	0.442	-0.340	-3.630	0.001
	NOOFCFL	-4.087	0.509	-0.998	-8.033	0.000
	RATIOCFLICL	-3.044	0.452	-0.623	-6.736	0.000
	RATIOCFLTUB	-2.366	0.377	-0.557	-6.278	0.000

Dependent Variable: SEC

The resulting regression equation obtained is,

$$Y = b_0 + b_1F_1 + b_2F_2 + b_3F_3 + \dots\dots\dots + b_nF_n \tag{1}$$

Where;

Y is Energy Efficiency (SEC) or Total Energy Consumption (Depending on the analysis required)

b_0 is Constant

$b_1, b_2, b_3, b_4, \dots, b_n$ are Coefficients of the independent variables

$F_1, F_2, F_3, F_4, \dots, F_n$ are Factor Scores

$$\begin{aligned} SEC &= 40.74 + 0.816 \times F_1 - 0.409 \times F_2 \\ &+ 0.210 \times F_4 - 0.224 \times F_5 + 0.516 \times F_6 \\ &+ 0.213 \times F_7 - 0.340 \times F_8 - 0.998 \times F_9 \\ &- 0.623 \times F_{10} - 0.557 \times F_{11} \end{aligned} \tag{2}$$

The ranking of factors based upon the beta values is shown in Table 8. From this table it is clear that in every commercial building the ‘number of CFLs used’ is the important factor for energy efficiency. It is a technical factor so this factor is directly proportional to the energy efficiency. The use of CFLs reduces the energy consumption as well as SEC and hence improves energy efficiency. The second most important factor is ‘economic factor’. Income, education, ownership, etc., are important variables of economic factor. As in residential sector, in commercial sector also the people think about the economic factors before adopting energy efficient technologies. Also, ‘ratio of CFLs to ICLs used’ and

'ratio of CFLs to tube lights used' are important factors as they are technical factors and are directly proportional to the energy efficiency.

Table 8: Ranking of Factors based on Beta Values for SEC

Factor	Beta value	Ranking
No. of CFLs used	-0.998	I
Economic factor	0.816	II
Ratio of CFLs to ICLs used	-0.623	III
Ratio of CFLs to Tube light	-0.557	IV
Subsidy factor	0.516	V
Technical factor	-0.409	VI
No. of Energy star products	-0.340	VII
Personal factor	-0.224	VIII
Knowledge factor	0.213	IX
Government Policy factor	0.210	X

The 'government policy factor' is the least factor in this regression analysis. The people think least about the government incentives and effort. Awareness, adequacy of information, etc., are the other main variables of the personal factor. The people have less awareness about the energy efficient technologies and also about general environmental issues. Also, the adequacy of information provided by the firms is not satisfactory.

Factors Influencing Total Energy Consumption (TEC)

Total ten variables are selected from the questionnaire in order to find the main factors which influence the TEC in commercial sectors. After completing the pilot study, a reliability test is conducted. Cronbach's alpha value obtained is 0.603.

The factor analysis is not necessary in this case because, the number of factors considered are less. Therefore, multiple regression analysis can be carried out directly. In this case, the Adjusted R^2 of 0.924 is obtained and it has a reasonably good explanatory power. R (Multiple correlation coefficients) value of 0.969 indicated a strong relationship between the dependent variable and the considered factors. The dependent variable is TEC. The standardized beta coefficients for all the factors are obtained by the Collinearity statistics table. It is found that only three factors, Concern for environment (CONCRNENV), Area of the building (AREA) and Cost of energy consumed (COSTOFENE) are significant. Out of ten variables, only these three variables are within the limit of significant values. For significant result the value should be less than 0.10. Therefore, for only three variables again regression analysis is carried out. By doing this the adjusted R^2 value is increased to 0.931. And again in these only two factors are significant (Table 9). The remaining CONCRNENV factor is not considered to form a regression equation because it is not significant. By using the beta coefficients the regression equation is formed.

Table 9: Collinearity Statistics for TEC

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-3112.927	8079.038		-0.385	0.702
	CONCRNENV	-1721.618	1769.565	-0.038	-0.973	0.336
	AREA	1456.993	818.173	0.073	1.781	0.082
	COSTOFENE	18090.310	786.427	0.931	23.003	0.000

Dependent Variable: TEC

The resulting regression equation is,

$$TEC = -3112.927 + 0.073 \times F_7 + 0.931 \times F_9 \quad (3)$$

Table 10: Ranking of Factors based on Beta values for TEC

Factor	Beta Value	Ranking
Cost of energy consumed	0.931	I
Area of the building	0.073	II

Only two factors influence the TEC in commercial buildings. From this table it is clear that in every commercial building the 'cost of energy consumed' is the important criterion for total energy consumption. This factor is directly proportional to the TEC. As the cost of energy increases, automatically TEC also increases and vice versa. The second most important factor is the 'area of the building'. As the area of the building increases the TEC also increases because in commercial buildings the area of lighting also increases.

CONCLUSIONS

In spite of the fact that commercial sector is vital component of Indian economy, it appears that energy related aspects of them have not much attracted the attention, at least at the micro level. In view of the present study it might be inferred that, there is significant scope for energy efficiency improvements in commercial sector. High degree of awareness about energy efficient technologies are to be created and economic & financial benefits are need to be supported for energy efficiency improvement and reduction in the environmental impact. Improvement in energy efficiency initiative can go a long way in the sustainable development.

REFERENCES

1. *ExxonMobil (2015), "The Outlook for Energy: A View to 2040". Retrieved from http://www.exxonmobil.com/energyoutlook*
2. *Ram Ganesh Yadav, et al. (2005), "India's Fast-Growing Power Sector: From Regional Development to the Growth of a National Grid", IEEE Power & Energy Magazine.*
3. *KREDL (Karnataka Renewable Energy Development Limited) (2009), "Karnataka Renewable Energy Policy 2009-14", Department of Energy, Government of Karnataka.*
4. *Gilchrist, A. (1995), "Linking Energy Efficiency into Company Objectives", Engineering Management Journal, December, pp.273-293.*
5. *Kamal, W.A. (1997), "Improving Energy Efficiency: The Cost-Effective Way to Mitigate Global Warming", Energy Conservation & Management, Vol.38, No.1, pp.39-59.*
6. *Reddy, B.S. (2003), "Overcoming the Energy Efficiency Gap in India's Household Sector", Energy Policy, Vol.31, pp.1117-1127.*
7. *Padmavathi K Umachagi, et al. (2015), "Study of Energy Consumption in Residential and Commercial Sector of Hubli City", International Journal for Innovative Research in Science and Technology, Vol.1, No.11, pp.83-91.*
8. *Bhattacharyya, S.C. (2010), "Shaping a Sustainable Energy Future for India: Management Challenges", Energy policy, Vol.38, pp.4173-4185.*

9. *EIA (Energy Information Administration) (2013), "International Energy Outlook 2013". Retrieved from http://www.eia.gov/forecasts/ieo/pdf/0484(2013).pdf*
10. *Kaza, N. (2010), "Understanding the Spectrum of Residential Energy Consumption: A Quantile Regression Approach", Energy Policy, Vol.38, pp.6574-6585.*